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The use of soda-lime for measuring respiration rates in terrestrial systems

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With 3 figures

1. Introduction

Forest floor respiration continues to be one of the most commonly measured parameters in ecosystem research. Ecologists have used it to balance ecosystem carbon budgets and to determine mineralization rates in nutrient cycling studies. Many studies on effects of acid rain on terrestrial ecosystems, forest fertilization research, and research on effects of hazardous chemicals released to the environment using both field and microcosm techniques measure soil respiration as one of the routinely monitored parameters for providing clues to possible functional imbalance in ecosystems. The most commonly used methods for measuring ecosystem respiration rates employ one of many alkali absorption techniques or infrared gas analysis. However, there are inherent problems with all of the methods used to date. The purpose of this paper is to address some of the problems and to present a technique with demonstrated advantages over other conventional methods.

The most commonly used techniques for measuring *in situ* forest floor respiration employ some type of chamber inverted over the forest floor for "trapping" CO_2. Two basic inverted chamber techniques have been designated as the "static" and the "dynamic" methods (Witkamp & Frank 1969). With the "dynamic" method, air is pumped from a mixing tank (Woodwell & Botkin 1970) or from surrounding air (Reiners 1968; Witkamp & Frank 1969; Edwards 1975, and others) through the inverted chambers. The air stream is monitored for CO_2 concentration before and after passing through the inverted chamber, using an alkali absorption solution or an infrared gas analyzer. The "static" method employs an inverted chamber sitting on the surface or a cylinder inserted a few centimeters into the soil, with CO_2 absorbed into an alkali solution placed within the chamber. The dynamic method has distinct advantages in terms of accuracy, especially if moving chambers and normal air flow rates are used to simulate natural microclimatic conditions (Edwards 1974). However, equipment required for the dynamic system is often too expensive and is virtually useless in remote areas where electric power may not be available. However, the static method using alkali solutions as the CO_2 absorbent is inefficient, absorbing only about 60% as much CO_2 as the dynamic method (Edwards & Sollins 1973; Kucera & Kirkham 1971). Alkali solutions, using either the dynamic or static method, present problems in winter because they often freeze. While this is generally a problem only on some winter nights in temperate regions, it is important to obtain measurements over entire 24-h periods because of diel patterns of forest floor respiration (Witkamp 1969, Edwards 1974, and Edwards & Sollins 1973). Another disadvantage of alkali solutions is the amount of time required for titration.

The soda-lime technique described in this paper was previously used in a laboratory soil incubation experiment (Minderman & Vulto 1973) and in the field by Howard (1966) and Monteith et al. (1964). Howard correctly observed that Monteith et al. did not take into account the water which is chemically released from soda-lime when it reacts with

carbon dioxide. Howard subsequently designed a "dynamic" field sampling system which used anhydrone (anhydrous magnesium perchlorate) for absorption of this chemically released water. In this paper, I describe a soda-lime technique which eliminates the necessity of using anhydron. I also demonstrate some precautions necessary if soda-lime is to be used successfully for measuring forest floor respiration. The method eliminates problems associated with alkali solutions while conserving the simplicity and versatility of the static method.

2. Methods

2.1. General

Soda-lime is useful for absorbing moisture and CO_2. Since CO_2 is chemically bound and the moisture is not, the soda-lime can be dried and weighed before and after a measurement period, with the difference in weight representing the amount of CO_2 absorbed minus the water released during the chemical reaction. The amount of chemically released water is predictable, thus permitting the use of a correction factor (to be discussed later in this paper). This simple technique was very appealing because measurement of soil CO_2 efflux in a large number of plots scattered over a large area was needed. However, it was necessary to address the following questions before the technique could be used with confidence: (1) how does the CO_2 absorption efficiency of soda-lime compare with that of the traditionally used alkali solutions? (2) how much and what surface area of soda-lime should be used for maximum absorption of CO_2 from a given soil surface area and over a given time period? (3) what is the effect, if any, of different humidity levels on CO_2 absorption efficiency? (4) how much CO_2 will a given weight of soda-lime absorb before its absorption efficiency declines significantly? (5) what is an appropriate drying time and temperature to use? and (6) can the amount of water released during the reaction of CO_2 with soda-lime and subsequently driven off upon drying be accurately predicted and therefore corrected for?

To address these questions, a number of carefully controlled laboratory and field experiments were conducted, using granular (6—12 mesh) soda-lime small enough for a large surface-to-volume ratio but large enough to prevent losses of fine particles during drying and handling. All field work was carried out in an oak-hickory forest in eastern Tennessee.

2.2. Comparisons with potassium hydroxide (KOH)

A 0.2 N KOH solution was used in all comparisons with soda-lime. The KOH was titrated with 0.1 N hydrocloric acid (HC1), and CO_2 absorbed was calculated according to BLACK (1965). Field comparisons were conducted in late summer 1980. Six plastic chambers (33 cm long × 20 cm wide × 12 cm deep) were inverted over the forest floor surface. A shallow plastic dish with a top surface area of 64 cm² containing 30 g of sola-lime (dried 24 h at 100 °C) was placed under each of three inverted chambers. A glass jar with the same top surface area (64 cm²) containing 75 mL of KOH was placed under each of the other three inverted chambers. Six identical chambers were inverted over "Plexiglas" sheets and used to measure ambient CO_2, three with KOH and three with soda-lime. All chambers were weighted down with stones. The chambers were left in place for 24 h before they were capped and returned to the laboratory for analysis.

Absorption efficiency comparisons were also conducted in the laboratory. Ten open containers (4.5-cm diam × 3.5 cm depth) of each absorbant (8 g soda-lime and 25 mL 0.2 N KOH) were placed side by side on a laboratory bench for measurements of ambient CO_2 over a 24-h period.

2.3. Quantity and surface area Comparisons

In this experiment, a total of 54 chambers (described above) were used. Half the chambers were placed on "Plexiglas" for ambient measurements and half were placed side by side on the adjacent forest floor surface (intact) and left for 24 h. Three different amounts (15, 30, and 40 g) of soda-lime were used in triplicate for both ambient and intact measurements. Three different exposed surface areas (16, 32, and 64 cm²) of soda-lime were used for each of the three different amounts used. The surface areas represented 2.5, 5, and 10% of the forest floor surface covered by the chambers.

2.4. Humidity effects, absorption capacity, and shelf life studies

In this experiment two sources of soda-lime were used. One source came from a half-empty jar which had been sitting on a shelf in the laboratory for about four months with the lid screwed down tightly. The other source was from a new, freshly opened container which had been sealed. Three grams of soda-lime from each source were placed in each of three containers, dried, and weighed. All weights were determined with a four-place analytical balance. These containers were

left open on a laboratory bench over a period of 30 d. They were periodically weighed, dried, re-weighed, and returned to the laboratory bench.

It was anticipated that humidity would vary more in our laboratory than CO_2 concentrations and that this would be reflected in our periodic measurements of water and CO_2 absorbed by the soda-lime.

2.5. Drying time and temperature

Soda-lime was removed from a freshly opened container and pre-dried for 2 h before being exposed to the atmosphere for 72 h. This was followed by drying and weighing at about 2-h inter-vals over a 24 h period. Some was dried at 100 °C and some at 80 °C. A second batch of soda-lime received the same treatment as above except that it was pre-dried for 24 h.

2.6. Correction factor for chemically released water

The chemical reactions which occur between CO_2 and soda-lime are:

$$2\ NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

and

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O.$$
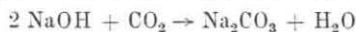
For every mole of CO_2 that is chemically bound in the soda-lime, a mole of water is released. Since the molecular weight of CO_2 is 44 and the molecular weight of water is only 18, the reaction results in a net weight gain in the soda-lime. However, upon drying at 100 °C, the water from the reaction is driven off along with water absorbed from the environment. Thus, merely obtaining dry weights of soda-lime before and after use underestimates CO_2 absorbed by 40%. Theoretically we only need to multiply CO_2 data obtained gravimetrically by a correction factor of 1.4 [(44 + 18)/44] to obtain accurate CO_2 measurements. This experiment was designed to test the reliability of this correction factor.

Sixty grams of dry soda-lime were placed in each of four glass absorption tubes. A nitrogen--carbon dioxide mixture containing 1,498 ppm CO_2 was bubbled through water (to add moisture) and then through the soda-lime-filled tubes at a flow rate of 62.4 L/h. Two tubes were used during one 4-h period and the other two tubes were used during a second period of 3.58 h. The gas stream exiting the soda-lime was monitored by infrared gas analysis (IRGA) and found to remain at zero throughout the experiments. At the end of the absorption periods the soda-lime was dried and weighed. The weight gain was then compared to the theoretical amount of CO_2 absorbed, based on CO_2 concentration in the tank, flor rate, and duration of the absorption period.

3. Results and discussion

3.1. Comparisons with KOH

KOH absorbed significantly ($P < 0.001$) less CO_2 than soda-lime in both field and la-boratory tests (Table 1). In the field tests, the variability was much higher with soda-lime (coefficient of variation = 12.8%) than with KOH (coefficient of variation = 5.8%). This difference in variability was not observed in the lab. Due to the small number of sam-ples in the field, the difference in variability cannot be considered conclusive, but intuitively the higher variability with soda-lime may reflect the natural spatial variability in forest floor respiration rates. The relatively low absorption efficiency of the KOH may have over-shadowed this natural variability.

Table 1. A comparison of CO_2 absorption between KOH (0.02 N) and soda-lime

Location[a]	Carbon dioxide (mg/d)	
	Soda-lime[b]	KOH[c] (0.02 N)
Field	2,730 ± 350	1,040 ± 60
Laboratory	103 ± 8	23 ± 2

[a] For field measurements, values are per m². In the laboratory, measurements were made without enclosures.
[b] 30 g in the field, 8 g in the laboratory.
[c] 75 mL in the field, 25 mL in the laboratory.
Note: Data shown as X (SD), n = 3 in field and 10 in laboratory.

In contrast to these data, similar comparisons at Coweeta Hydrologic Laboratory in North Carolina showed 1.0 N NaOH to be a slightly more efficient CO_2 absorber than soda-lime (JACK WAIDE, personal communication). Since NaOH and KOH undergo identical chemical reactions with CO_2, the normality of the alkali would appear to be the factor effecting differences in results. However, GUPTA & SINGH (1977) showed that increasing the normality of NaOH from 0.25 N to 0.75 N had no effect on CO_2 absorption capacity when adequate volumes of NaOH were used. MINDERMAN & VULTO (1973) showed essentially the same results. MINDERMAN & VULTO also showed the CO_2 absorption efficiency of soda-lime to be twice that of 2.0 N KOH in their measurements of "undisturbed" soil samples enclosed in glass jars. Recent comparisons at the University of Alaska (KEITH VAN CLEVE, personal communication) also showed soda-lime to be a more efficient absorber of CO_2 than KOH. The cause of the discrepancy between results from these studies and those at Coweeta is not clear at this time.

3.2. Comparisons with infrared gas analysis

No direct field comparisons with infrared gas analysis were made during this study. However, routine monthly measurements of forest floor CO_2 efflux using soda-lime in another study here at ORNL compare favorably with IRGA measurements made previously at an adjacent site (EDWARDS 1975).

The IRGA measurements were made using very low air flow through chambers that were automatically raised from the forest floor between short periods of measurement to prevent moisture build-up under the chambers (EDWARDS 1974). Soda-lime is very hygroscopic and, therefore, serves somewhat the same function as moving chambers. However, this hygroscopic characteristic of soda-lime may result in excessive dryness in laboratory incubations where small volumes of substrate are used, or in field sites where moisture may be limiting to respiratory activity.

3.3. Quantity and surface area of soda-lime

Results of this experiment (Table 2) indicate that increasing the quantity and/or the surface area of soda-lime per unit area of forest floor results in increased net CO_2 values. With the weight of soda-lime held constant at 15 g, net CO_2 values were increased by 320% by increasing the top surface area of the soda-lime 300% (from 16 to 64 cm²). An identical increase in net CO_2 was observed with the surface area held constant at 16 cm² and increasing the amount of soda-lime used (from 15 to 50 g). In one case, a decrease in net CO_2 was observed with an increase in soda-lime surface area (from 32 to 64 cm² with 30 g soda-lime). This probably is a reflection of the high natural spatial variability in CO_2 efflux rates from the forest floor. Note the relatively high standard deviation values for the 30-g to 64-cm² combination. Generally the net CO_2 values increased more by increasing both surface area and weight than by increasing only one or the other. However, except for the one outlier discussed above, no statistically significant ($P < 0.01$) increase in net CO_2 values was observed by using surface areas exceeding 32 cm² (5% of the forest floor surface being measured) and amounts of soda-lime greater than 30 g.

3.4. Shelf life, humidity effects, and absorption capacity

We observed no significant difference in CO_2 absorption efficiency between freshly opened soda-lime and soda-lime that had been opened occasionally over a four month period and stored in the laboratory in a screw-top glass jar (Fig. 1). Concerns about humidity effects were also not warranted. The data show that the moisture absorbed by the soda-lime varied considerably from day to day, while the absorption rate of CO_2 decreased at a constant rate until it reached zero at 29 d. The lower CO_2 absorption rate between day 1 and day 5 is puzzling, but may reflect an initial delay period during the first few hrs for the soda-lime to become activated (by absorption of water). Such a lag was not observed using flow-

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Table 2. A comparison of *in situ* CO_2 efflux measurements with varying surface area and weights of soda-lime

Surface area (cm²)	Soda-lime weight		
	15 g	30 g	40 g
16	1.49 ± 0.44	3.69 ± 0.76	4.78 ± 0.30
32	4.06 ± 1.05	6.12 ± 1.29	7.46 ± 1.65
64	4.78 ± 0.30	4.08 ± 2.72	7.50 ± 0.27

Values are net CO_2 efflux in g m^{-2} d^{-1} $\pm$ 1 SD. Measurements were made over a 660-cm² area of forest floor.

-through systems (see section on chemical water-loss correction factor). This lag should present problems only in arid regions and possibly during periods of extremely low humidity. At times when humidity is low, it would de advisable to pre-moisten the soda-lime or to increase the humidity by allowing water to evaporate from a beaker placed under the chambers. This would be especially important for ambient chambers that do not benefit from moisture evaporation from the soil.

The zero CO_2 absorption capacity of soda-lime was reached when the weight of the CO_2 absorbed reached $\sim 28\%$ of the initial soda-lime weight. This agrees quite closely with the label on some soda-lime containers which indicates that soda-lime will absorb amounts of CO_2 equal to 25% of the soda-lime by weight. However, the efficiency of absorption de-
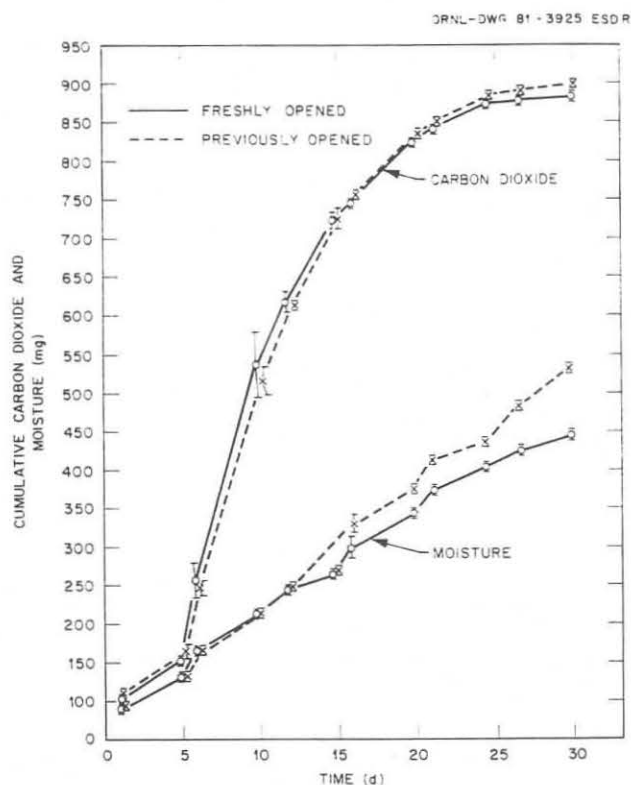

Fig. 1. The effects of shelf life and moisture uptake on rates of CO_2 uptake by soda-lime. Data points are means, and bars are standard deviations (n = 3).

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Table 3. Changes in CO_2 absorption efficiency of soda-lime as CO_2 is absorbed

Time (d)	CO_2/soda-lime[a] (%)	CO_2 absorbed/d		Absorption efficiency
		Observed (mg)	Expected (mg)	(Observed/expected) (%)
4.9— 5.8	7.0	120	120	100
5.8— 9.8	16.2	69	120	58
9.8—11.7	18.9	43	120	36
11.7—14.7	22.5	36	120	30
14.7—15.8	23.2	21	120	18
15.8—19.9	25.9	19	120	16
19.9—21.2	26.4	11	120	9
21.2—24.4	27.5	10	120	8
24.4—26.6	27.6	2	120	2
26.6—29.7	27.9	3	120	2

[a]) The cumulative weight of CO_2 absorbed over time, divided by the initial weight of soda-lime. Observed CO_2 absorbed/d is based on data shown in Fig. 1.

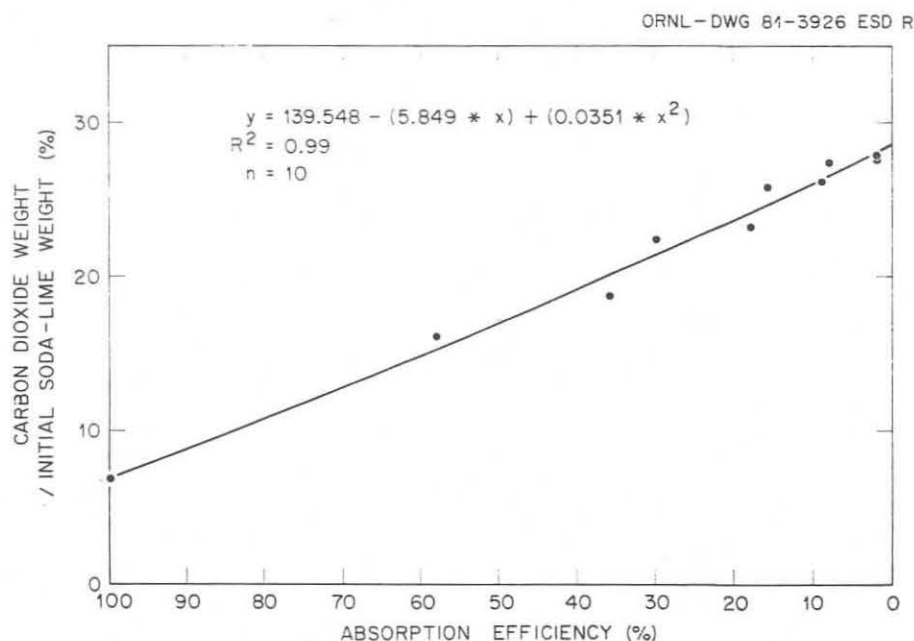$$y = 139.548 - (5.849 * x) + (0.0351 * x^2)$$
$$R^2 = 0.99$$
$$n = 10$$

Fig. 2. The relationship between CO_2 absorption efficiency of soda-lime and the amount of CO_2 already absorbed.

clines predictably until it reaches zero. Using the maximum rate of absorption (during the 5th and 6th days) as the expected efficiency of 100 %, an absorption efficiency (observed absorption/expected absorption) was calculated for each measurement (Table 3). A regression analysis showed a highly significant correlation ($r^2 = 0.99$) between absorption efficiency and the ratio of CO_2 absorbed to initial weight of soda-lime used (Fig. 2).

3.5. Drying time and temperature

Soda-lime that was pre-dried for 24 h at 100 °C required only about 8 h at 100 °C to reach constant dryness after being exposed to ambient CO_2 for 72 h in the laboratory. Apparent CO_2 (final dry wt — initial dry wt) of the soda-lime after 2 h drying time was 1.4
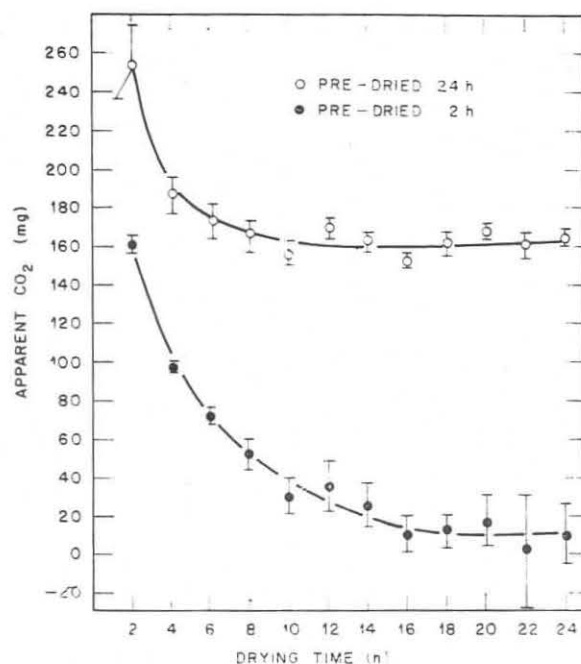
Fig. 3. The effect of pre-drying time and drying time on calculated amounts of CO_2 absorbed by the soda-lime after exposure to ambient CO_2 concentrations in the laboratory. Drying temperature was 100 °C. Curves were fitted by eye. Data points are means, and bars are standard deviations (n = 2 and 4 for 2- and 24-h pre-dried data, respectively).

times that of soda-lime dried for 4 h and 1.5 times that of soda-lime dried for 8 h. Further drying did not significantly change the weight of the soda-lime. As illustrated in Fig. 3, the length of pre-drying greatly affected the length of time required to reach complete dryness after the 72 h exposure period. Soda-lime that was pre-dried for only 2 h required 16 h to reach constant dryness after 72-h exposure to ambient CO_2. It is interesting to note that the apparent CO_2 absorbed was equal to ~161 mg after 2-h drying of the soda-lime that was pre-dried for 2 h and almost exactly the same (163 mg) after 24-h drying of soda--lime pre-dried for 24 h. Therefore, the assumption can be made that ~160 mg (uncorrected for chemical water loss — see below) of CO_2 was indeed the amount of CO_2 absorbed over the 72 h period. With the 2-h pre-dried soda-lime, data collected after 24 h drying time indicated that the amount of CO_2 absorbed was only 10 mg, nearly twenty times lower than the "correct" amount. This is easily explained by recognizing the fact that the 2-h pre--drying period was not adequate to remove all the moisture from the soda-lime. Since the soda-lime was dried for longer than 2 h after use, the difference between the pre-dry weight and the final dry weight (the apparent CO_2 absorbed) was less than it would have been if the soda-lime had been completely dried initially. In fact, it is possible that the apparent CO_2 absorbed could have been negative if CO_2 absorption rates had been extremely low relative to the amount of moisture remaining in the soda-lime dried for only 2 h.

The suggestion by MONTEITH et al. (1964) that 2 h is optimal drying time for soda-lime must be considered in light of the data presented above. I suggest that for consistency the soda-lime should be dried completely before and after using. This will vary with conditions, such as whether the soda-lime is spread out in a thin layer or packed in a column. For convenience, I now dry soda-lime a minimum of 24 h before and after use. If placed in a dessicator immediately upon removal from the oven and removed only long enough to be

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weighed and then restored in the dessicator, the soda-lime may be re-used without re--weighing.

3.6. Correction factor for chemically released water

Calculated correction factors based on gravimetric measurements of soda-lime and theoretical values based on a known concentration of CO_2 passing through the soda-lime at constant flow ranged from 1.27 to 1.43 (Table 4). The calculated mean value of 1.38 is not significantly different from the theoretical value of 1.41.

Table 4. A comparison of CO_2 absorbed in soda-lime vs calculated amount of CO_2 released into the soda-lime from a known source concentration

Flask No.	Carbon dioxide (mg)		
	Theoretical[a]	Measured[b]	Correction factor[c]
1	660	519	1.27
2	660	465	1.42
3	591	428	1.38
4	591	414	1.43
X	626	457	1.38

[a] Values were calculated from known concentrations of CO_2 in tank (1,498 ppm) at constant flow (62.4 L/h) over measured time (4 h for flasks 1 and 2, 3.58 h for flasks 3 and 4). Weight of CO_2 was calculated after correction for temperature and atmospheric pressure.
[b] Values represent differences in dry weight of soda-lime before and after absorption period.
[c] Theoretical ÷ measured. The values agree quite closely with the theoretical value of 1.41 for the correction of water lost during the chemical reaction of CO_2 with soda-lime.
Note: After passing through the soda-lime, the gas stream was monitored by infrared analysis and found to remain at zero throughout the experiment.

4. Conclusions and recommendations

It is concluded from these results that, under static conditions, soda-lime absorbs CO_2 more efficiently than alkali solutions such as KOH. Also, the efficiency of CO_2 absorption by soda-lime decreases at rates predictable from the weight ratio of CO_2 absorbed to the initial amount of soda-lime used. I suggest that if the weight of CO_2 absorbed has reached nearly 7% of the initial weight of soda-lime used that it be discarded and fresh soda-lime used. An alternative is to correct for the decrease in absorption efficiency, using a predictive equation such as the one reported here.

Soda-lime can be stored in a screw-top glass bottle for months without decreasing its absorption efficiency. Although soda-lime absorbs CO_2 only when it is moist, it will absorb variable amounts of moisture without affecting the rates of CO_2 absorption within the range of moisture conditions existing at the time of these experiments.

Soda-lime should be dried to constant dryness before and after each use. I found that drying for 8 h at 100 °C is adequate, but, for convenience, drying overnight or longer may be advisable. It is also advisable to store soda-lime in a desiccator immediately upon removal from the drying oven.

Measured values of net CO_2 efflux from the forest floor will vary with relative amounts and surface area of soda-lime used per unit area of forest floor. Based on results reported here, I recommend, for forest floors with CO_2 efflux rates comparable to or less than those in the temperate zone, that ~30 g soda-lime by used per 500 cm² of forest floor and that the soda-lime be placed in a container with a surface area equal to about 5% of the surface area of forest floor being measured. It is also concluded that a correction factor of 1.4 should be used to correct for chemical water lost during the drying process.

Based on a limited field comparison of the static soda-lime technique and IRGA in combination with moving chambers, the soda-lime technique described here is perhaps as accurate as any available for measuring absolute rates of forest floor CO_2 efflux. This conclusion assumes that the IRGA-moving-chamber technique does indeed measure absolute rates. Based on a relatively complete carbon budget for a temperate deciduous forest in Tennessee (REICHLE et al. 1972), the IRGA — moving-chamber method provided a reasonable estimate of carbon flux from that forest floor.

5. Zusammenfassung

Die Verwendung von Soda-Kalk zur Messung von Respirationsraten
in terrestrischen Systemen

Eine körnige Mischung von Soda und gelöschtem Kalk wurde als möglicher alternativer Indikator an Stelle von Alkali-Lösungen zur Absorption von respiriertem CO_2 geprüft. Bei dem festen Gemisch von Soda und Kalk gibt es keine Probleme mit dem Einfrosten oder mit dem Verschütten von Testsubstanz. Auch die Titration ist nicht nötig, sondern nur die gravimetrische Ermittlung der Trockengewichte des Soda-Kalk-Gemisches vor und nach der Absorptionsperiode.

In unseren Experimenten hat eine 0,2 N KOH-Lösung unter gleichen Freilandbedingungen in einem gemischten Eichen-Hickory-Forst (in Tennessee) 38% und unter Laboratoriumsbedingungen (sogar) nur 22% der gleichzeitig vom Soda-Kalk-Gemisch absorbierten CO_2-Menge gebunden. Im Freiland variierten die auf verschiedenen Parzellen gemessenen CO_2-Mengen stärker, wenn Soda-Kalk statt KOH als Absorbens verwendet wurde. Diese Variabilität war jedoch anscheinend eine Widerspiegelung der aktuellen räumlichen Verschiedenheit der CO_2-Ausscheidung; dagegen war unter den ausgeglichenen Bedingungen im Laboratorium die Variabilität ziemlich gering (SD ca. 8% der mittleren Respirationsrate), und sie war hier etwa gleich bei Verwendung von Soda-Kalk und KOH. In den Freilandparzellen wurden proportional größere Zunahmen der Netto-CO_2-Kapazität durch die Zunahme des Gewichts pro Oberflächeneinheit hervorgerufen als durch die Zunahme der Oberfläche pro Gewichtseinheit. Keine signifikanten Zunahmen der CO_2-Bindung (p < 0.01) wurden bei Soda-Kalk-Oberflächen von mehr als 32 cm² (das entspricht 5% der gemessenen Waldboden-oberfläche) und bei Substanzmengen von mehr als 30 g beobachtet. Die Absorptionseffizienz (beobachtete Absorption/erwartete Absorption) tendierte vorhersagbar von nahezu 100% bei einem Soda-Kalk-Gewichtsverhältnis von 0,07 zu nahezu 0%, wenn das CO_2/Soda-Kalk-Mengenverhältnis 0,28 erreichte.

Versuche zeigten, daß Soda-Kalk über mehrere Monate hinweg ohne erhebliche Einschränkung seiner CO_2-Absorptions-Kapazität in mit Schraubdeckeln verschlossenen Glasbehältern aufbewahrt werden kann.

Es zeigte sich auch, daß (im Bereich der untersuchten Feuchtigkeitsbedingungen) die absorbierte Feuchtigkeitsmenge die Menge des absorbierten CO_2 nicht beeinflußte. Es wurde gezeigt, daß das Soda-Kalk-Gemisch (auch wenn es zuvor nicht benutzt wurde) vor und nach Gebrauch bei 100 °C ca. 8 h lang bis zur Gewichtskonstanz getrocknet werden sollte.

Experimente, bei denen bekannte Mengen von CO_2 in das Soda-Kalk-Gemisch geleitet wurden, zeigten die Wichtigkeit der Korrektur des Wasserverlustes während der Reaktion von CO_2 mit Soda-Kalk: sie ergaben einen Korrekturfaktor von ~1,4.

6. Acknowledgements

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Synopsis: Original scientific paper

A granular mixture of sodium hydroxide and slaked lime, was tested as a potential alternative to alkali solutions for absorbing carbon dioxide (CO_2) as an indicator of soil respiration rates. Because soda-lime can be used as a solid, problems with freezing and spillage are eliminated. Also, no titration is necessary; the only measurement needed is the dry weight of the soda-lime before and after the absorption period.

A 0.2 N solution of potassium hydroxide (KOH) absorbed 38% as much CO_2 as soda-lime measured simultaneously under identical field conditions and only 22% as much in the laboratory. In the field, variability between plots was much greater with soda-lime than with KOH. However, this variability was apparently a reflection of actual spatial variability of soil CO_2 efflux, because under homogeneous conditions in the laboratory variability was quite low (SD ca. 8% of the mean) and about the same for both KOH and soda lime. In field plots, greater proportional increases in net CO_2 absorptive capacity were produced by increasing the weight per unit surface area than by increasing the surface area per unit weight. No significant ($P < 0.01$) increase in net CO_2 values was observed with soda-lime surface exceeding 32 cm² (5% of the measured forest floor surface) and amounts greater than 30 g. The absorption efficiency (observed/expected absorption) declined predictably from near 100% at a CO_2/soda-lime weight ratio of 0.07 to near 0% when the CO_2/soda-lime ratio reached 0.28.

Soda-lime can be stored for several months in a glass screw-top container without significantly affecting CO_2 absorbing capacity. The amount of moisture absorbed did not affect the amount of CO_2 absorbed. Soda-lime (including soda-lime not previously used) should be dried to constant dryness (requiring ~8 h at 100 °C) before and after each use. Experiments in which known amounts of CO_2 were released into soda-lime demonstrated the importance of correcting for loss of water during the reaction of CO_2 with soda-lime and verified that the factor is ~1.4.

Key words: CO_2-efflux, soil respiration rates, absorption, absorptive capacity, carbon dioxide, odium and potassium hydroxide.